1GSI

UNIT - 3

CHEMISTRY FOR CLASS IX

Substances - Their Separation and Purification

BRAHM PRAKASH

राष्ट्रीय शैक्षिक अनुसंधान और प्रशिक्षण परिषद्
National Council of Educational Research & Training
Sri Aurobindo Marg, New Delhi 110016

March, 1988

DESM-2T

© National Council of Educational Research & Training

Published at the Department of Education in Science and Mathematics by the Secretary, National Council of Educational Research & Training, Sri Aurobindo Marg, New Delhi-110016 and Printed at the Pradeep Art Press, 36, Adhchini, Mehrauli Road, New Delhi 110017.

PREFACE

The present series of twelve chemistry units has been developed for try-out of the Individually Guided System of Instruction (IGSI) in class IX. The description of IGSI and first two units of this series of units are available under a separate cover. This new system of instruction and the units have been developed along the lines of the National Policy on Education (NPE-86) and involve the participation of pupils in the process of learning. The units are suited for self-study with occasional help from a tutor. In the present context, these units will serve an examplar self-study material for secondary stage chemistry. In developing this unit, I was assisted by some of the chemistry teachers

This unit contains an introduction for motivation, arousing interest, and to link the present unit with preceding and next units. The objectives given in this unit are the expected learning outcomes, so that the pupil will know the ultimate goals he has to achieve. The suggested reading material provided in the unit guides the pupil to achieve pre-stated objectives. A number of intext and post-text questions, activities, and problems have been included to provide enough practice and chance for self evaluation.

The suggestions for the improvement of this unit will be welcomed.

BRAHM PRAKASH
Reader
Department of Education
in Science & Mathematics
N.C.E.R.T. New Delhi

March, 1988

I. Introduction

In the last unit, we studied about the existence of matter in three states, namely solid, liquid and gaseous We come across and use the materials in their three states in our day-today life. We take both the solid and liquid food every day. Whenever we are offered a clear water like drink, we look for any visible impurity in it. Also, we do not know the taste of the drink just from its appearance. On tasting, when we find that the taste of the drink is salty or sweet, we say that the drink contains salt or sugar dissolved in it. We can look through some of these liquid drinks. On the otherhand if we observe milk contained in a glass tumbler, we can not see through it. Thus various solutions exhibit different types of properties. In this unit, we shall study the different types of solutions, and some of their properties.

Also, in the last unit we studied the classification of matter into elements, mixtures and compounds. In nature, more than 80% of the material is found in the form of mixture. For a meaningful utilization of all the components of the mixture and to study their chemistry, it is necessary to get the components of the mixture in their pure form. In this unit, we shall study the techniques of separation and purification of substances.

II. Objectives

After completing this unit, you should be able to

1. Identify the characteristics of true solution, colloidal solution and suspension and state the differences between them.

2. Suggest methods of separation of the components of various types of mixtures.

3. Describe the methods of purification of various substances.

4 State the techniques for testing the purity of substances.

III. Suggested Reading Material

3 1 Solution and Suspension

If we stirr a little salt or sugar with water, the solid vanishes and the water tastes salty or sweet. The solid does not settle on standing. The mixture thus obtained remains transparent. We call this transparent mixture a *solution* Water is the *solvent* and salt or sugar, the *solute*

Salt solution = Salt + Water

solution = *solute* + *solvent*

Such solutions are also called *true-solutions*. The composition of the components of true solution is uniform through out. Such a solution is called a homogeneous solution. If the composition in a sample is not uniform through out the sample, it is heterogeneous For example, a mixture of sand and salt.

Now let us try the experiment in which the soil is stirred with some water in a glass or beaker and allowed to stand. After about five minutes we shall find that :

(a) some or most of the soild settles to the bottom.

(b) the water above the settled portion is turbid.

We can not easily see through it; it is not transparent Observation (a) tells us that there are particles that are heavy. They settle down. Observation (b) shows that there are smaller particles that are lighter. They do not settle down but float in water (remain suspended). This turbid part of the mixture of soil and water is called a *suspension* of soil particles in water. If the suspension is kept overnight, some more particles settle down. The rate of settling depends on two factors;

(a) the size of particle : the bigger particles settle faster.

(b) the density of the particle · of two different particles of equal size and shape, the heavier will settle faster.

Perform another simple experiment. Take some slaked lime in a small spoon and stirr in half a glass of water. It will form a white suspension. Allow it to settle overnight. Interpret what you observe.

Activity using Filter-Paper

What happens if we try to filter a true solution through an ordinary filter-paper ? We find that the solution passes through it.

If we filter a suspension, it will let the water pass through and hold back the residue (suspended particles).

Now perform filtration experiment using turmeric powder-water mixture and see if it is a suspension.

Particle Size · Let us consider the true solution and suspension prepared in above activities. When salt dissolves in water, 'salt particles' break up into very tiny pieces and dissolve in water. They become so small that we do not see them and also they pass through filter-paper.

In case of suspensions, we can see some of the suspended particles with our naked eyes. So, the particles are bigger.

3.2 Colloidal Solutions

Let us dissolve a little powdered soap in water. Stirr and allow to stand. We shall obtain a soap solution. Can we see through it ? Perhaps a little or not at all It does not settle on standing. If we try to filter it, it passes through the filter-paper. We do not really see the

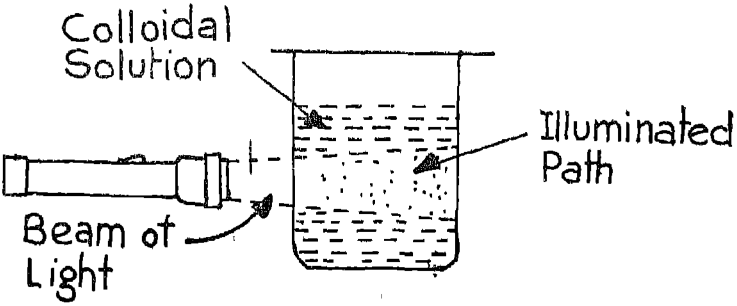

Fig. 3.1 Light falling on colloidal solution

particles of soap but we know that the particles are present. We say that the soap in water forms a *colloidal solution.* Let us perform another experiment. Take three clean glasses or beakers. Fill one with clear salt solution, the second with soil suspension and the third with soap solution. Put each one of these solutions in the path of a beam of light as shown in figure 3.1. Observe from the side in a direction perpendicular to that of the light beam.

Observations :

1. The true solution will allow the light to pass through without adding extra illumination to the solution.

2. The suspension will allow light to pass through it. The suspended particles get illuminated. We can see the particles.

3. The colloidal solution (soap solution) will allow the light to pass through it. The path of the beam of light gets illuminated and becomes visible. We can not see the colloidal particles. Inside the solution, light is reflected by the very tiny colloidal particles. As a result of this the beam gets illuminated.

4. A colloidal solution contains particles of size bigger than the particles of true solution but smaller than that of suspension. Two properties of suspension, colloidal solution and true solution are listed in table 3.1

Table - 3.1

Nature of mixture	Suspension	Colloidal Solution	True Solution
1. Particle size	0.2×10^{-4} cm or more	In between suspension and true solution	10^{-7} cm. or less
2 Visibility of particles.	Visible, more so under the microscope.	Not visible	Not visible

Some examples of colloidal solutions

We can easily identify solutions and suspensions. The following are some examples :- gum, paste, starch solution, tooth paste, blood, gelatin, ink, detergent and soap form colloidal solutions with water. Starch, gum, gelatin etc. are compounds with giant molecules.

Questions

1. If we add a table spoon of milk to half a glass of water and shake, we obtain a mixture. What experiment would you perform to show that it is a colloidal solution ?

2 If you mix phenyle or 'dettol' in water, it gives a white mixture. From their observed nature, they too are colloids. Will these mixtures pass through ordinary filterpaper.

3. A suspension is not homogeneous. What do you call such a mixture ?

3.3 Separation of Components of a Mixture

There are three types of mixtures according to their physical states In this unit, we shall study about different types of the mixtures of two components.

Table—3.2

Types of two components mixtures

S No.	Type	Example
1.	Solid — Solid	Mixture of sand and salt
2.	Solid — Liquid	Sugar dissolved in water
3.	Liquid — Liquid	Alcohol dissolved in water
4.	Liquid — gas	Soft drinks-campa cola, etc.

Let us study some of the methods of separating components of a mixture and purifying them The use of particular method for separating the components of a mixture depends on the nature of the components. Some of these methods are described below :

3. 31 Separation of components of solid - solid mixture

(a) By hand picking : When the comonents of a mixture are sufficiently large, they can be separated by hand picking. For example we remove stones from rice, wheat grains or pulses in our home by hand picking.

(b) By floatation : This technique is used when one component of a mixture is lighter and the other heavier than water. For example, when a mixture of saw dust and iron filings is treated with water, saw dust floats (lighter than water) and iron filings settle down (heavier than water).

(c) **By solution formation :-** On treating the mixture with a suitable solvent one component dissolves and the other is left behind For example, when water is added to a mixture of common salt and sulphur, common salt dissolves and sulphur remains behind. This is then separated by filtration. Common salt is obtained from filtrate by evaporating water.

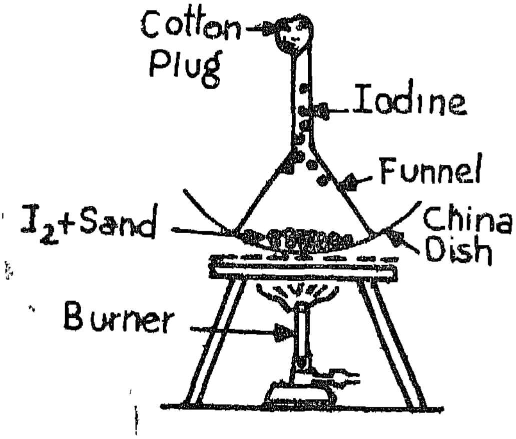

Fig. 3.2 Sublimation

(d) **By sublimation**: Sublimation is a process in which a solid directly changes into gaseous state on heating (for example ammonium chloride, iodine, camphor). This process can be used when one of the component in a mixture has a property of sublimation. For example, when a mixture of iodine and sand is heated under a funnel in a china dish, iodine vaporizes and condenses on the upper cooler part of the funnel. Sand remains in the china dish.

(e) By magnetic separation: If the components of the mixture have magnetic properties, they can be separated by moving it close to a strong magnet.

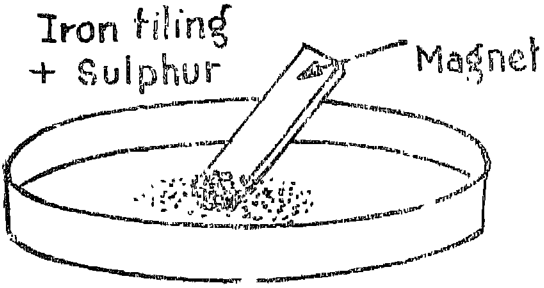

Fig. 3.3 Separation of iron and sulphur from mixture.

3. 32 Separation of components of solid-liquid mixture

(i) When the solid is insoluble in the liquid

(a) **By filtration**: This method is used, when solid is insoluble in the liquid. Consider an example of the mixture of water and sand. Set up the apparatus for the filtration as shown in Fig 3.4. Transfer the mixture in the filter paper cone with the help of a glass rod. During filtration, the level of the mixture in the cone should always be 2 cm below the edge of the cone. The liquid collects in the beaker palced below the stem of the funnel and the solid remains in the filter paper cone Thus the two constituents are separated. This process of separating the liquid from the solid is called filtration

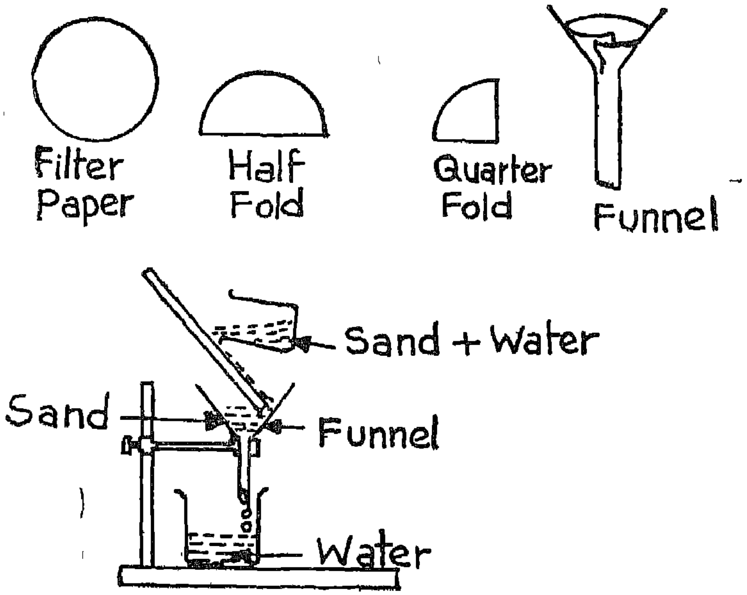

Fig. 3.4 Filtration

(b) **By decantation** : This process is applied when insoluble solid particles settle down in a liquid. The liquid is poured out carefully.

(ii) when the solid is soluble in the liquid.

(a) **By evaporation** : On evaporating the mixture the liquid evaporates and solid is left behind. For example, when a solution of copper sulphate is heated, water gets evaporated and solid copper sulphate remains behind in the dish. This method is suitable only when the solid is required and the solvent is allowed to escape. If both solid and liquid are to be separated, we use the distillation process.

(b) **By distillation** : The solution is taken in a distillation flask fitted to a condenser and heated as shown in Fig 3.5. On heating, the liquid evaporates. The vapour gets cooled in the condenser and changes to liquid which collects in the receiver flask. Solid is left behind in the distillation flask. Thus both constituents are separated. If the mixture contains only two liquid components with different boiling points, the liquid with lower boiling point, distills first. Then the other liquid starts distilling.

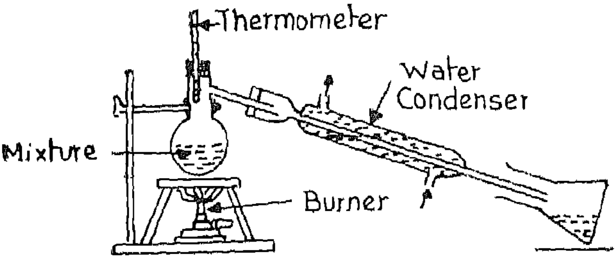

Fig. 3.5 Distillation

(c) By crystallisation : In this method the solid is obtained in the form of crystals. The solution is concentrated by heating in a china dish. The concentrated solution is then cooled. On cooling the solid crystallises out.

3. 33 Mixture of two liquids

By using separating funnel : Those liquids which do not mix but form separate layers are known as immiscible liquids. Such liquids are separated by using a separating funnel. The mixture is allowed to stand in a separating funnel. The heavier liquid forms the lower layer and is run-off by opening the tap of the funnel. The lighter liquid which forms the upper layer is left in the flask. For example, a mixture of kerosene and water can be separated by this method. Water is heavier than kerosene. So it forms lower layer and can be removed first.

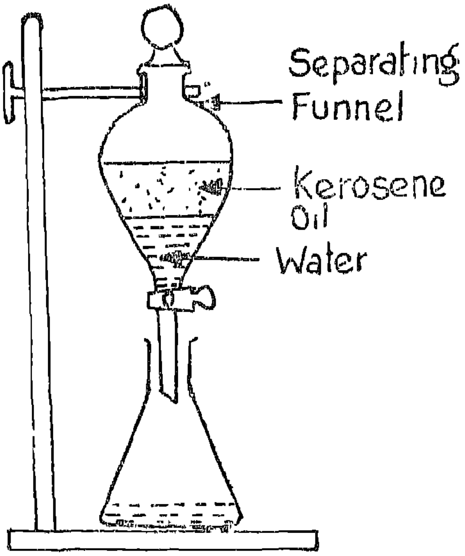

Fig. 3.6 Separation of immiscible liquids

3.34 Mixture of a liquid and a gas

The mixture of a gas in liquid is separated by heating. This is based on the principal that solubility of gases in liquids decreases with rise in temperature. For example, air dissolved in water comes out on heating. It is observed that when a beaker containing water is heated, bubbles of air come out of water and collect in the test tube. (Fig. 3.7)

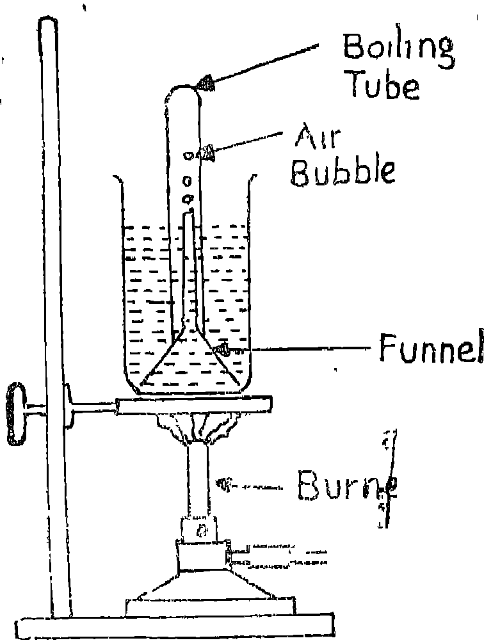

Fig. 3.7 Separation of gas from liquid

Student's Activity :- Repeat the same experiment with soda water. Raise the temperature of soda water carefully.

3.4 Purification of Solid Substances

Any component separated from a mixture is likely to be contaminated with small quantities of other components of the mixture. The component therefore needs further purification It can be done either by repeating the process or using some simple techniques A common technique used to purify solids is known as crystallisation.

Crystallisation : The solid to be purified is dissolved in a suitable solvent till saturated solution is obtained. This saturated solution is evaporated in an evaporating dish till the crystallisation point reaches. (Crystallisation point is a stage where on slight cooling of the solution, solid crystals appear). Then on slow cooling, crystals of pure substance are obtained and the impurities are left behind in the solution.

3.5 Test of Purity

The purity of solids and liquids can be tested by determining their melting and boiling points respectively.

3.51 Determination of Melting point

Take a beaker and fill it half with water. In this, put a glass tube containing solid compound whose melting point you have to determine. Heat the beaker gently over wire gauze. Suspend the thermometer, as shown in Fig. 3.8 to record the rise in temperature. Heat the beaker gently and note the temperature at which solid compound starts mleting ? Check the rise in temperature by removing the flame.

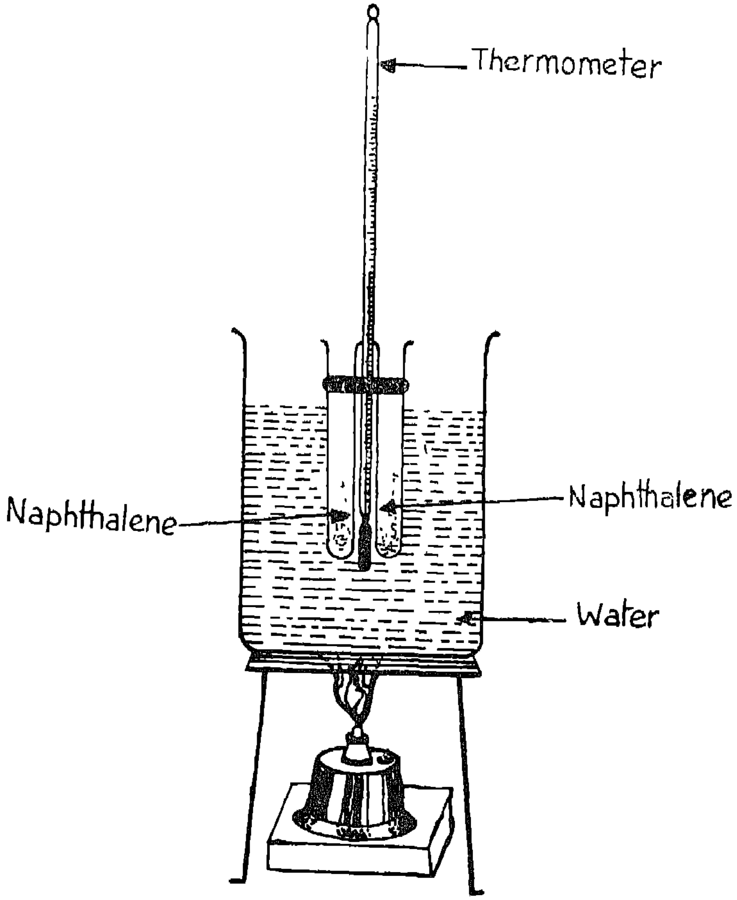

Fig. 3.8 Determination of melting point.

Determination of boiling point : Any pure liquid would boil under normal atmospheric pressure at a definite temperature, called the boiling point of the liquid. It can be determined by setting the apparatus as shown in Fig. 3 8. Fill half of the beaker with water. Put in it a test tube containing a liquid whose boiling point is to be determined. Put a capillary tube in the tube containing liquid. Suspend a thermometer as shown in Fig. 3 8 to record the rise in temperature. Heat the beaker gently. Note the temperature at which the liquid starts boiling. Check the temperature by removing flame. Compare it with the boiling point of pure liquid.

IV Home Assignment

1. Add 50 c.c. water to about 2 grams common salt contained in a glass tumbler and stirr. The salt dissolves and forms a solution. How can the salt be recovered from the solution ?

2. State whether the following statements are true or false.

   a. A solution is a homogeneous system.

   b Iodine dissolves readily in water but not in alcohol.

   c. Soda water is a solution of oxygen in water.

   d. Powdered sugar dissolves faster than sugar crystals.

3. Choose the correct word to complete the following statements.

   a. The particles of ………… size settle faster in a suspension (bigger/smaller)

   b. When the components of a mixture are sufficiently large, they can be separated by ……………………… (hand picking/sublimation)

   c Liquid pairs which do not mix but form separate layers are known as ……………………… (immiscible liquids/miscible liquids)

V Self assessment

1. In a solution of solid iodine in carbon tetrachloride (It is a liquid), identify the solute and the solvent
2. Give three examples of solid, substances that form colloidal solution with water.
3. Milk is a colloidal solution. Give three properties that would distinguish it from a true solution.
4. Explain why the path of a beam of light gets illuminated while passing through a colloidal solution ?
5. Give three properties that distinguish between suspension, colloid and true solution.
6. Suggest a technique for
   - (a) separation of the components of a mixture containing sugar and sand.
   - (b) testing the purity of a substance.

Teacher'e Guide

The idea of true solution, colloids and suspension may be discussed in the class. The scattering of light by colloidal particles may be demonstrated. Learning the techniques of separation and purification of substances is best done through the experiments Therefore the unit requires several demonstrations, such as the techniques of separation, purification and testing of purtty of substances, to be shown in the class. The students may be asked to perform activities involving the techniques of filtration, decantation magnetic separation and crystallization

Demonstration-1 **The technique of sublimation** may be demonstrated in the class by using a mixture of sodium chloride and ammonium chloride The procedure is described in the unit. During the discussion, it may be clearly brought out that in sublimation, a substance changes from solid phase directly into the vapour phase without changing into the liquid phase

Demonstration-2 The technique of **distillation** may be demonstrated in the class as described in the unit.The need for improvisation of apparatus may also be emphasised in the class In this, one can make use of the fused electric bulbs. The coils of bulbs are removed carefully and these can be used as distillation flask and receiver. Simultaneously testing the purity of liquids by determining their boiling points may be explained. The boiling point of a liquid substance can be determined by the same distillation apparatus.

Demonstration-3 **The Crystallization** technique may be demonstrated using benzoic acid. Water is used as a crystallizing solvent.

Students activities : The students may be asked to determine the melting point of one solid substance in the laboratory or science room.

Magnetic Separation :- The students may be asked to separate iron and copper powder from a mixture with the help of a bar magnet. The powder may be taken in petri dish. When the bar magnet is brought near the mixture, it will be noticed that iron particles stick to the magnet while copper remains in the dish.